Bias and Precision of Age Estimates

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May 18, 2017

```
Age <- read.csv("Data/Raw-Data/2016_largemouth-bass_age-estimates_raw.csv") %>%
  dplyr::select(FID:Difference) %>%
  arrange(FID)
Age$FID <- factor(Age$FID)
length(Age$FID)
```

```
## [1] 132
```

```
Age[Age$FID==55,];FID55 <- as.numeric(rownames(Age[Age$FID==55,]))
```

```
##    FID AgerA AgerB AgerC Difference
## 55  55     2     2     2         NO
```

```
Age <- Age[-c(FID55),] %>%
  filterD(!is.na(FID)) ### Remove outliers
length(Age$FID)
```

```
## [1] 131
```

```
str(Age)
```

```
## 'data.frame':    131 obs. of  5 variables:
##  $ FID       : Factor w/ 131 levels "1","2","3","4",..: 1 2 3 4 5 6 7 8 9 10 ...
##  $ AgerA     : int  4 4 4 6 4 NA 1 2 4 8 ...
##  $ AgerB     : int  4 4 4 6 4 NA 1 2 4 8 ...
##  $ AgerC     : int  4 4 4 6 4 NA 4 2 4 8 ...
##  $ Difference: Factor w/ 2 levels "NO","YES": 1 1 1 1 1 NA 2 1 1 1 ...
```

```
#write.csv(Age,file="Data/Clean-Data/2016_largemouth-bass_age-estimates_clean.csv")
```

Comparing Age Estimates Between 3 Readers

```
ab.AB <- ageBias(AgerA~AgerB, data=Age, ref.lab = "Ager B", nref.lab = "Ager A")
```

```
ab.AC <- ageBias(AgerA~AgerC,data = Age,ref.lab = "Ager C", nref.lab = "Ager A")
```

```
ab.BC <- ageBias(AgerB~AgerC,data = Age,ref.lab = "Ager C", nref.lab = "Ager B")
```

Bias

Three readers made indipendant reads of Largemouth Bass otoliths to determine the age of Largemouth Bass in our sample. Now we will look for bias between the 3 readers (readers A, B, C). We will use age bias plots to do this.

Bias Alex (AgerA) vs Jim (AgerB) Age Est.

```
plot(ab.AB, col.CIsig = "Black", show.range = TRUE, main = "", bty = "n", lwd = 2,
    lwd.CI = 2, lwd.range = 2, lwd.agree = 2, col.CI = "red", col.range = "red",
    cex.n = 1.25, cex.axis = 1.5, yaxt = "n", xlab = "", ylab = "")
```

```
## Warning in plot.window(...): "cex.n" is not a graphical parameter
```

```
## Warning in plot.xy(xy, type, ...): "cex.n" is not a graphical parameter
```

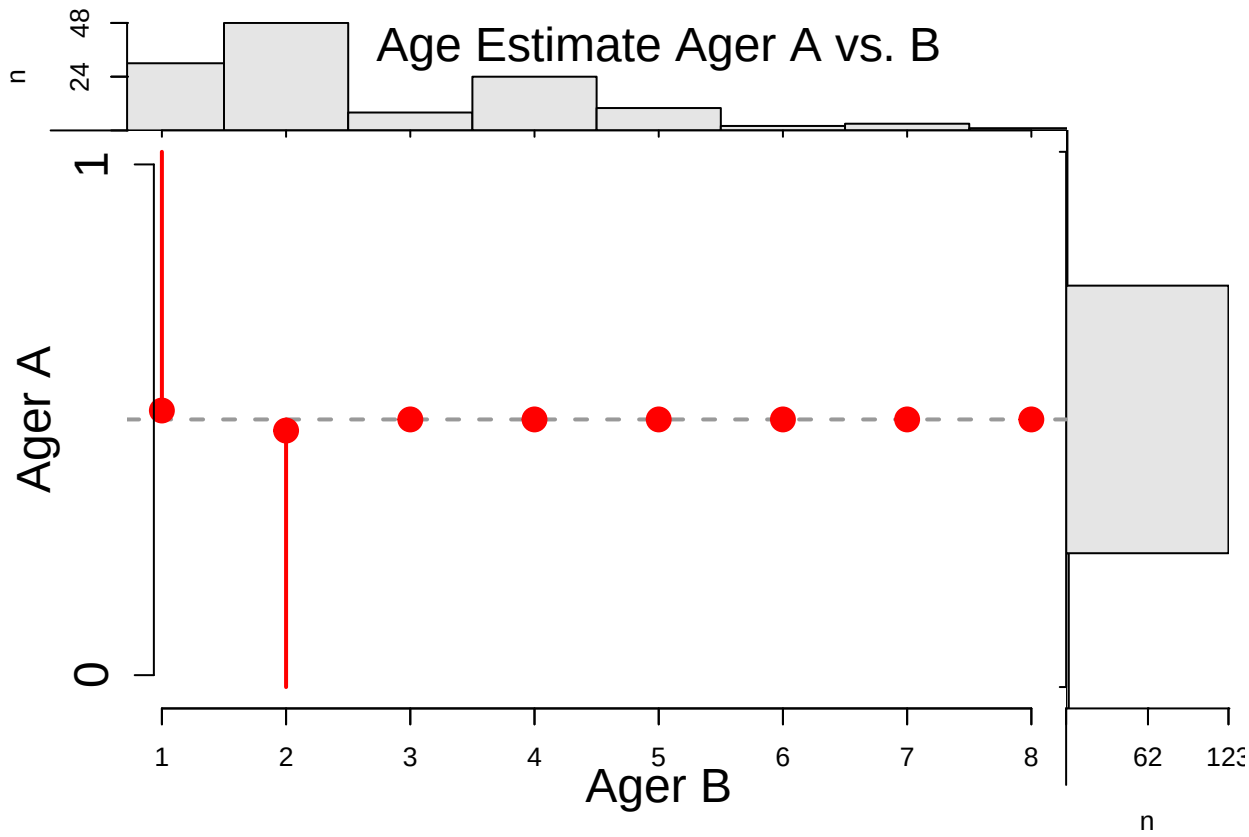
```
## Warning in axis(side = side, at = at, labels = labels, ...): "cex.n" is not
## a graphical parameter
```

```
## Warning in axis(side = side, at = at, labels = labels, ...): "cex.n" is not
## a graphical parameter
```

```
## Warning in box(...): "cex.n" is not a graphical parameter
```

```
## Warning in title(...): "cex.n" is not a graphical parameter
```

```
axis(2, at = seq(0, 8, 1), cex.axis = 1.5)
mtext("Ager A", side = 2, cex = 1.5, line = 2.5)
mtext("Ager B", side = 1, cex = 1.5, line = 2.5)
mtext("Age Estimate Ager A vs. B", side = 3, cex = 1.5, line = 2.5)
```




```
### Statistics behind age bias plot
SumAB.bias <- summary(ab.AB, what = "bias")
```

```
##  AgerB  n min max mean     SE     t adj.p   sig   LCI  UCI
##      1 30   1   2 1.03 0.0333  1.00 0.326 FALSE 0.965 1.10
##      2 48   1   2 1.96 0.0291 -1.43 0.319 FALSE 1.900 2.02
##      3  8   3   3 3.00     NA    NA    NA FALSE    NA   NA
##      4 24   4   4 4.00     NA    NA    NA FALSE    NA   NA
##      5 10   5   5 5.00     NA    NA    NA FALSE    NA   NA
##      6  2   6   6 6.00     NA    NA    NA FALSE    NA   NA
##      7  3   7   7 7.00     NA    NA    NA FALSE    NA   NA
##      8  1   8   8 8.00     NA    NA    NA FALSE    NA   NA
```

```
summary(ab.AB, what = "symmetry")  ### Alex's age est (A) not biased compared to Jim (B)
```

```
##       symTest df    chi.sq         p
## 1     McNemar  1 0.3333333 0.5637029
## 2 EvansHoenig  1 0.3333333 0.5637029
## 3      Bowker  1 0.3333333 0.5637029
```

```
summary(ab.AB, what = "table")
```

```
##       Ager B
## Ager A  1  2  3  4  5  6  7  8
##      1 29  2  -  -  -  -  -  -
##      2  1 46  -  -  -  -  -  -
##      3  -  -  8  -  -  -  -  -
##      4  -  -  - 24  -  -  -  -
##      5  -  -  -  - 10  -  -  -
```

```
##       6  -  -  -  -  -  2  -  -
##       7  -  -  -  -  -  -  3  -
##       8  -  -  -  -  -  -  -  1
```

Bias Alex (AgerA) vs Steve (AgerC) Age Est.

```
plot(ab.AC, col.CIsig = "Black", show.range = TRUE, main = "", bty = "n", lwd = 2,
    lwd.CI = 2, lwd.range = 2, lwd.agree = 2, col.CI = "red", col.range = "red",
    cex.n = 1.25, cex.axis = 1.5, yaxt = "n", xlab = "", ylab = "")
```

```
## Warning in plot.window(...): "cex.n" is not a graphical parameter
```

```
## Warning in plot.xy(xy, type, ...): "cex.n" is not a graphical parameter
```

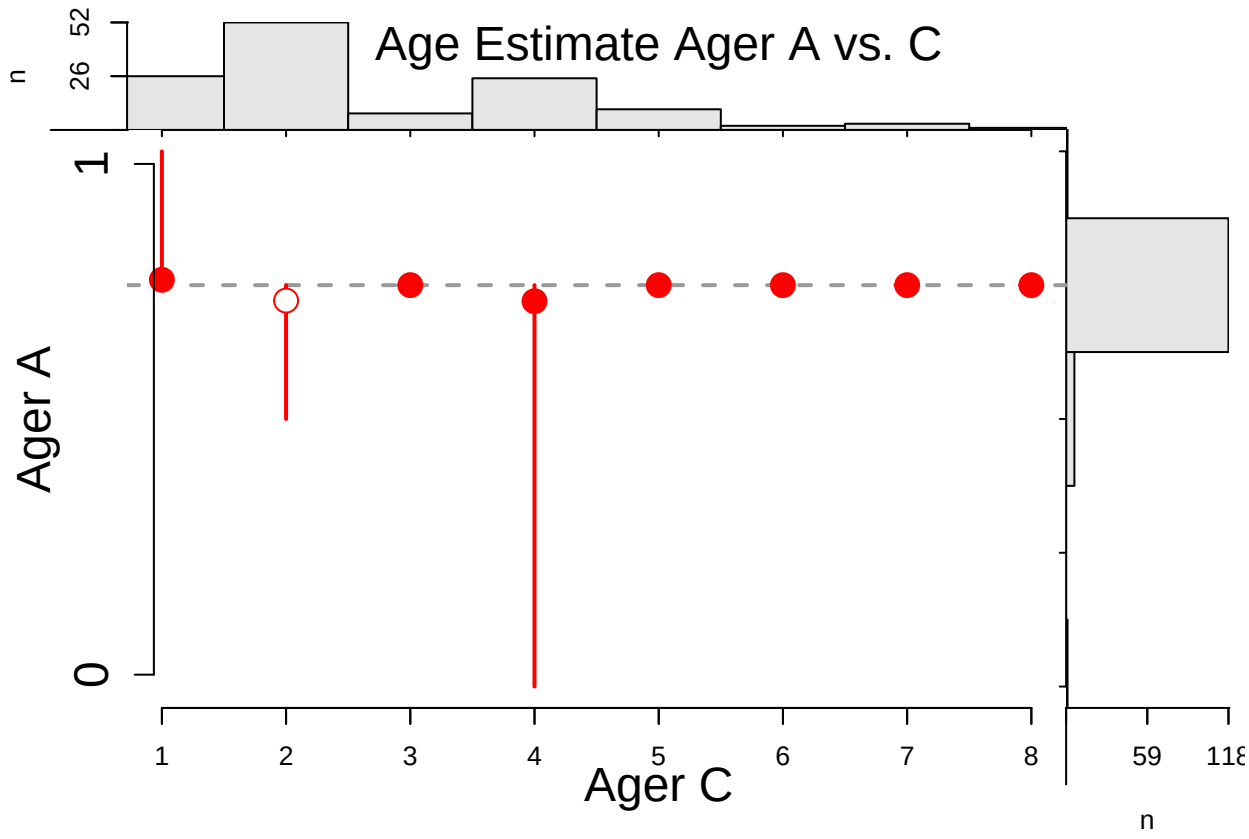
```
## Warning in axis(side = side, at = at, labels = labels, ...): "cex.n" is not
## a graphical parameter
```

```
## Warning in axis(side = side, at = at, labels = labels, ...): "cex.n" is not
## a graphical parameter
```

```
## Warning in box(...): "cex.n" is not a graphical parameter
```

```
## Warning in title(...): "cex.n" is not a graphical parameter
```

```
axis(2, at = seq(0, 8, 1), cex.axis = 1.5)
mtext("Ager A", side = 2, cex = 1.5, line = 2.5)
mtext("Ager C", side = 1, cex = 1.5, line = 2.5)
mtext("Age Estimate Ager A vs. C", side = 3, cex = 1.5, line = 2.5)
```



```
### Statistics behind age bias plot
SumAC.bias <- summary(ab.AC, what = "bias")
```

```
##  AgerC  n min max mean     SE     t  adj.p   sig   LCI  UCI
##      1 26   1   2 1.04 0.0392  1.02 0.6352 FALSE 0.959 1.12
##      2 52   1   2 1.88 0.0447 -2.58 0.0385  TRUE 1.795 1.97
##      3  8   3   3 3.00     NA    NA     NA FALSE    NA   NA
##      4 25   1   4 3.88 0.1200 -1.00 0.6352 FALSE 3.632 4.13
##      5 10   5   5 5.00     NA    NA     NA FALSE    NA   NA
##      6  2   6   6 6.00     NA    NA     NA FALSE    NA   NA
##      7  3   7   7 7.00     NA    NA     NA FALSE    NA   NA
##      8  1   8   8 8.00     NA    NA     NA FALSE    NA   NA
```

```
summary(ab.AC, what = "symmetry")  # McNemar Suggests some age Bias between Alex and Steve
```

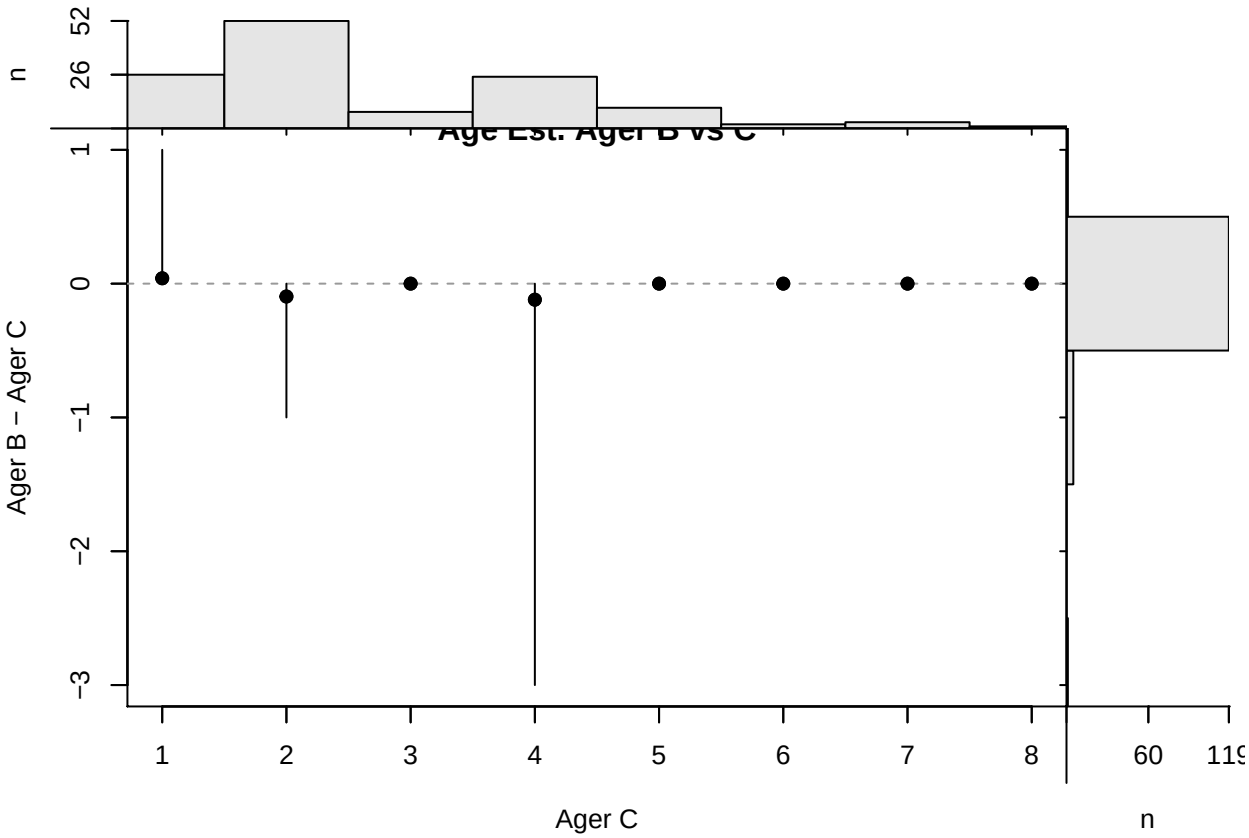
```
##       symTest df   chi.sq          p
## 1     McNemar  1 4.500000 0.03389485
## 2 EvansHoenig  2 4.571429 0.10170139
## 3      Bowker  2 4.571429 0.10170139
```

```
summary(ab.AC, what = "table")
```

```
##       Ager C
## Ager A  1  2  3  4  5  6  7  8
##      1 24  6  -  1  -  -  -  -
##      2  1 46  -  -  -  -  -  -
##      3  -  -  8  -  -  -  -  -
##      4  -  -  - 24  -  -  -  -
##      5  -  -  -  - 10  -  -  -
##      6  -  -  -  -  -  2  -  -
##      7  -  -  -  -  -  -  3  -
##      8  -  -  -  -  -  -  -  1
```

Bias Steve (AgerC) vs Jim (AgerB) Age Est.

```
plot(ab.BC, col.CIsig = "Black", show.range = TRUE, main = "Age Est. Ager B vs C")
```


n
52
26
Age Est. Ager B vs C
Ager B – Ager C
1
0
−1
−2
−3
1
2
3
4
5
6
7
8
60
119
Ager C
n

```
### Statistics behind age bias plot
summary(ab.BC, what = "bias")
```

```
##  AgerC  n min max mean     SE     t  adj.p   sig   LCI  UCI
##      1 26   1   2 1.04 0.0392  1.02 0.6352 FALSE 0.959 1.12
##      2 52   1   2 1.90 0.0413 -2.33 0.0715 FALSE 1.821 1.99
##      3  8   3   3 3.00     NA    NA     NA FALSE    NA   NA
##      4 25   1   4 3.88 0.1200 -1.00 0.6352 FALSE 3.632 4.13
##      5 10   5   5 5.00     NA    NA     NA FALSE    NA   NA
##      6  2   6   6 6.00     NA    NA     NA FALSE    NA   NA
##      7  3   7   7 7.00     NA    NA     NA FALSE    NA   NA
##      8  1   8   8 8.00     NA    NA     NA FALSE    NA   NA
```

```
summary(ab.BC, what = "symmetry")  # close but no age bias between jim and steve
```

```
##       symTest df   chi.sq          p
## 1     McNemar  1 3.571429 0.05878172
## 2 EvansHoenig  2 3.666667 0.15987975
## 3      Bowker  2 3.666667 0.15987975
```

```
summary(ab.BC, what = "table")
```

```
##       Ager C
## Ager B  1  2  3  4  5  6  7  8
##      1 24  5  -  1  -  -  -  -
##      2  1 47  -  -  -  -  -  -
##      3  -  -  8  -  -  -  -  -
##      4  -  -  - 24  -  -  -  -
##      5  -  -  -  - 10  -  -  -
##      6  -  -  -  -  -  2  -  -
##      7  -  -  -  -  -  -  3  -
##      8  -  -  -  -  -  -  -  1
```

Precision

We will assess precision of age estimates using average coeficcient of variance but will also look at some other metrics.

```
ap.ABC <- agePrecision(~AgerA + AgerB + AgerC, data = Age)

summary(ap.ABC, what = "difference")
```

```
##                     -3      -2      -1       0       1
## AgerA - AgerB  0.0000  0.0000  1.5873 97.6190  0.7937
## AgerA - AgerC  0.7937  0.0000  4.7619 93.6508  0.7937
## AgerB - AgerC  0.7937  0.0000  3.9683 94.4444  0.7937
```

```
SumABC.Prec <- summary(ap.ABC, what = "precision")
```

```
##    n validn R   ACV   APE PercAgree
##  131    126 3 3.162 2.434     92.86
```

FID	AgerA (Alex)	AgerB (Jim)	AgerC (Steve)
7	1	1	4
27	1	1	2
29	1	1	2
34	1	1	2
35	1	2	2
63	1	2	2
71	2	2	1
90	2	1	2
122	1	1	2

There is some dissagreement about the age of some fish (FIDs 7,27,29,34,35,63,71,90,122) and some have not been aged at all (FIDs 6,28,79,81,124). I may remove these fish when fitting the growth model.

Age estimates were similar between all three readers (AgerA, AgerB, and AgerC). AgerA was found to underestimate the ages of 2 year old fish when compared to AgerC (t =-2.58, p = 0.038) but not when compared to AgerB (t = -1.43, p = 0.319). We found no other significant bias in the age estimations made by the three readers. **Fish with inconsistent age estimates** ($n = 9$) **were removed from later analysis to eliminate this bias [(or) will be assigned ages based on the majority agreement between 2 readers]**. Overall, there was a high level of precision between age estimates provided by our three readers ($n = 126$, 92.86 % Agreement, ACV = 3.16).